Effects of Mining on Health :

Evidence from Copper Mining in Zambia

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Presentation Structure

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Questions

- Is the presence of natural resources a ‘divine blessing’ or a curse?
- Should a country endowed with natural resources anticipate prosperous times or fear an increase in poor health outcomes as a result of pollution”?
- How does the increase in copper production affect the health outcomes of the local communities?
- And what about the causal impact of natural resource booms resulting from the exogenous shocks from international copper prices on health outcomes?

Motivation

- What is the effect of the exogenous shock to the international copper price on health outcomes?

- Quasi-experimental evidence
  - Volatile copper prices lead to an increase in copper production
  - Health outcomes in constituencies close to the mines likely to be affected
  - Reverse causality between natural resource extraction and health outcomes
  - Possible endogeneity of natural resource extraction

Literature

- Cross country evidence of a natural resource curse (Sachs and Warner)

- Papers on natural resources and health outcomes: Aragon and Rud (2016) and Greenstone and Jack (2015) and Arceo-Gomez et al (2016)

- Papers on copper and the economy in Zambia focus on air pollution: Ncube et al (2012)

Contributions

- Detailed analysis on mechanisms of the impact of natural resources on the health outcomes of local economies within a single country.

- Establishing how natural recourses causally impact health outcomes in local communities.

- Contribute to growing literature by examining the impact of natural resources on local economies at a subnational level.

- Using a novel dataset which has not been used in any studies thus contributing to the empirical studies on the impact of mining on health outcomes in a developing country and resolving endogeneity issues of natural resource extraction.

Data and Variables

- Household survey data from LCMS for 5 waves (1996, 1998, 2004, 2006 and 2010)- aggregated at constituency level- CSO Zambia

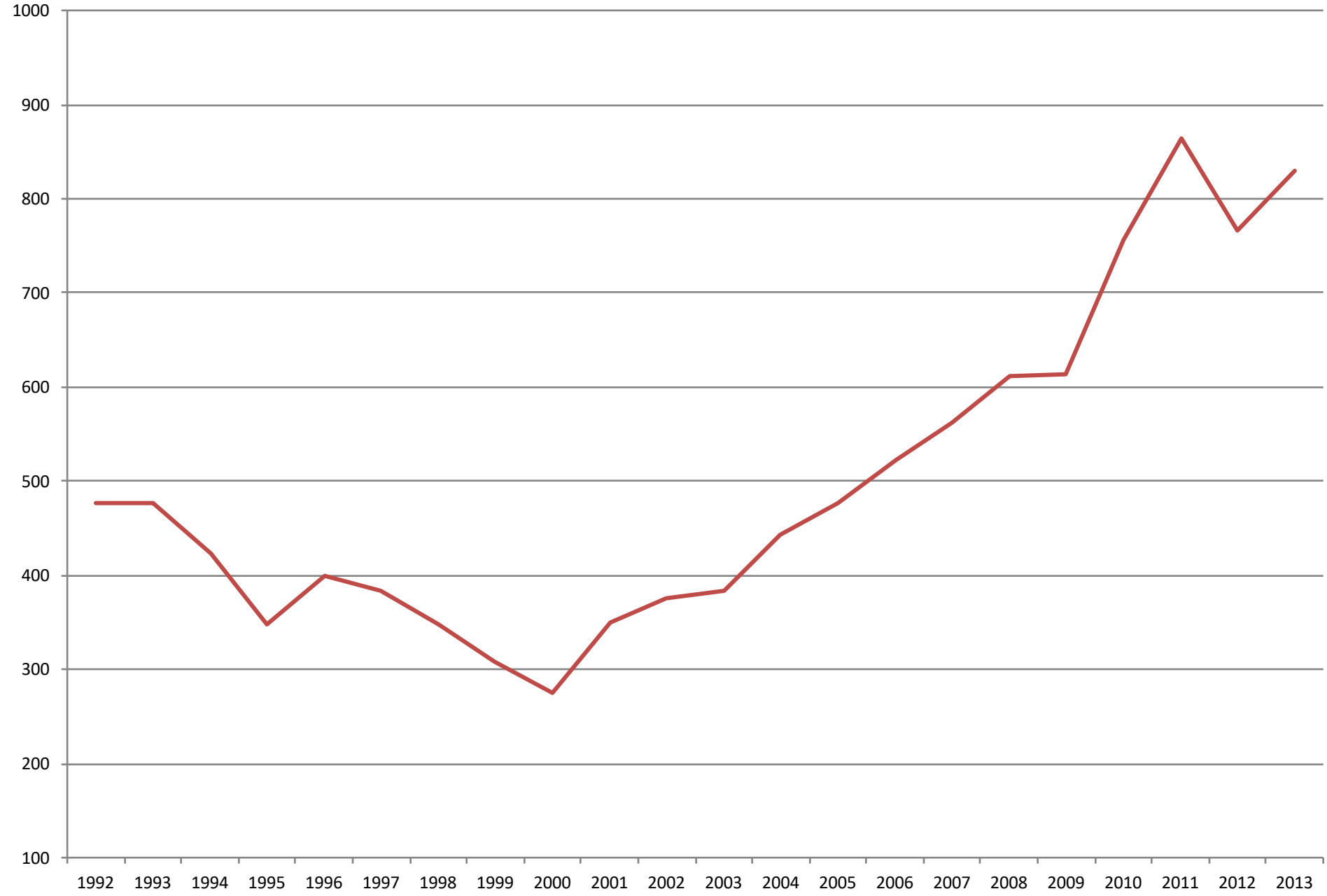
- Copper production and copper prices- Mines annual reports, Ministry of Mines and Minerals Development, Westmetall, BoZ and the World Bank

  - Main outcome variable-health outcomes, copper production used as proxy for pollution (non-availability of data on pollution levels).

  - Control Variables-Constituency characteristics: population density, age, household size, government expenditure, access to clean water and female headed households.

- Take into consideration the distance to the nearest mine to take into account the heterogeneous effects of distance
    - Group constituencies into those close to the mines and far away from the mines
    - Distance ranges from 1 to 912km with median distance of 200km separating constituencies close to and far away from the mines
    - Levels of pollution likely to change after the copper boom in 2003

Figure 1: Total copper production (in metric tons), by Year



Estimation

- Dependent Variables: Health outcomes: General sickness, anaemia, chest infections and diarrhoea

- In the case of the copper boom, this begun in 2003

- I focus on the direct impact of copper production and so my period of analysis is between 1996 and 2010 (period of increases in copper production)

Potential endogeneity of copper production reported in past literature, therefore use IV estimation

$$ln(\boldsymbol{y_{c,t}}) = \propto_{\boldsymbol{c}} + \boldsymbol{\beta_t} + \boldsymbol{\beta}_1 lnM_{\boldsymbol{c,\,t}} + \boldsymbol{\beta}_2 X_{\boldsymbol{c,\,t}} + \boldsymbol{\varepsilon_{c,t}} \quad \textbf{(1)}$$

$$lnM_{\boldsymbol{c,\,t}} = \boldsymbol{\lambda_c} + \boldsymbol{\tau}_t + \boldsymbol{\delta}\, ln\boldsymbol{IntCP_t} + \boldsymbol{\beta_2}\, \boldsymbol{X_{c,t}} + \boldsymbol{\mu_{c,t}} \quad \textbf{(2)}$$

where:

- $\boldsymbol{y_{c,t}}$ is a measure of health outcomes in constituency c in year t
- $lnM_{\boldsymbol{c,t}}$ is the natural log of per capita mine level copper output in constituency c in year t
- $ln\boldsymbol{IntCP_t}$ is the natural log of the international copper price and is used to instrument $lnM_{\boldsymbol{c,\,t}}$ in year t
- $\boldsymbol{X_{c,\,t}}$ is a vector of all control variables

Results

- Increases in diarrhoea cases in constituencies close to the mines at a higher level than those far away from the mines
- Significant decline general health outcomes
- Health outcomes dependent on mine type (comparatively poor health outcomes with presence of underground mines)
- Changes in real incomes have a significant impact on health outcomes.

Table 1: Effect of Ln (Copper Output) on the Health Outcomes

	Dependent Variables			
Panel 1-Second Stage	**General Sickness**	**Anaemia**	**Chest infections**	**Diarrhea**
	(1)	(2)	(3)	(4)
Independent Variables	2SLS FE	2SLS FE	2SLS FE	2SLS FE
Ln (Per capita mine level Copper output)	-0.076***	-0.167***	0.088***	0.079***
	(0.019)	(0.036)	(0.023)	(0.021)
R-squared	0.218	0.421	0.642	0.482
Observations	750	750	750	750
Constituency FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	ALL	ALL	ALL	ALL
Panel 2-First Stage				
Instrumental Variable				
International Copper Price	2.750***	2.750***	2.746***	2.756***
	-0.468	-0.468	-0.468	-0.469
F-statistic	34.47***	34.47***	34.47***	34.53***
P-Value	0.000	0.000	0.000	0.000
Kleibergen-Paap	0.000	0.000	0.000	0.000
Anderson Rubin	0.000	0.000	0.000	0.000
Stock-wright	0.000	0.000	0.000	0.000

Table 2: Effect of Ln (Copper Output) on Health Outcomes by Mine Type

Panel 1-Second Stage	**General Sickness**	**General Sickness**	**Chest Infections**	**Chest Infections**	**Anaemia**	**Anaemia**	**Diarrhea**	**Diarrhea**
Independent Variables	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Per capita mine level copper output	-0.052	-0.098***	0.01	0.136***	-0.087	-0.225***	0.072	0.088***
	(0.035)	(0.019)	(0.041)	(0.026)	(0.054)	(0.036)	(0.043)	(0.024)
Mine Type	Open pit	Underground	Open pit	Underground	Open pit	Underground	Open pit	Underground
R-squared	0.048	0.032	0.17	0.126	0.17	0.187	0.645	0.056
Observations	165	585	165	585	165	585	165	585
Panel 2-First Stage								
Instrumental Variable								
International Copper Price	3.824**	2.206***	3.824**	2.206***	3.824**	2.206***	3.824**	2.204***
	-0.1785	-0.24	-0.1785	-0.24	-0.1785	-0.24	-0.1785	-0.24
F-statistic	4.59**	84.73***	4.59**	84.73***	4.59**	84.73***	4.59**	84.83***
P-Value	0.04	0.000	0.04	0.000	0.04	0.000	0.04	0.000
Kleibergen Papp	0.04	0.000	0.04	0.000	0.04	0.000	0.04	0.000
Anderson Rubin	0.006	0.000	0.003	0.000	0.003	0.000	0.000	0.000
Stock Wright	0.003	0.000	0.002	0.000	0.002	0.000	0.000	0.000

Robustness Tests

- Results robust to alternatives:
  - Alternative groups of samples
    - Analysing urban constituencies separately from rural constituencies.
    - Using additional control variables to validate earlier findings.
    - Additional measures: Real Income and Poverty levels

Table 3: Effect of Ln (Copper Output) on Health Outcomes by Rural/Urban Status

Panel 1-Second Stage	**General Sickness**	**General Sickness**	**Chest Infections**	**Chest Infections**	**Anaemia**	**Anaemia**	**Diarrhoea**	**Diarrhoea**
Independent Variables	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE	2SLS FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Per capita mine level copper output	-0.155**	-0.043**	0.018	0.145***	-0.293**	-0.120***	0.112**	0.071*
	(0.049)	(0.016)	(0.034)	(0.041)	(0.089)	(0.036)	(0.035)	(0.027)
Mine Type	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
R-squared	0.087	0.827	0.1	0.193	0.161	0.215	0.753	0.395
Observations	230	520	230	520	230	520	230	520
Panel 2-First Stage								
Instrumental Variable								
International Copper Price	2.990***	2.457***	2.990***	2.457***	2.299***	2.457***	2.990***	2.472***
	(0.743)	(0.571)	(0.743)	(0.571)	(0.743)	(0.571)	(0.743)	(0.573)
F-statistic	16.17***	18.48***	16.17***	18.48***	16.17***	18.48***	16.17***	18.58***
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen Papp	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Anderson Rubin	0.000	0.000	0.632	0.000	0.000	0.000	0.000	0.000
Stock Wright	0.000	0.000	0.519	0.000	0.000	0.000	0.000	0.000

Table 4: Effect of Ln(Copper output) and Ln(Real Incomes) on Health outcomes

Panel 1-Second Stage	**General Sickness**	**Chest Infections**	**Anaemia**	**Diarrhoea**
	2SLS FE	2SLS FE	2SLS FE	2SLS FE
Independent Variables	(1)	(2)	(3)	(4)
Ln (Per capita mine level copper output)	-0.061***	0.080***	-0.139***	0.059***
	(0.013)	(0.018)	(0.026)	(0.016)
Ln (Real income per capita)	-0.147***	0.095	-0.281***	0.137***
	(0.038)	(0.054)	(0.078)	(0.037)
R-squared	0.467	0.396	0.883	0.491
Observations	750	750	750	750
Panel 2-First Stage				
Instrumental Variable				
International Copper Price	3.367***	3.367***	3.367***	3.373***
	(0.479)	(0.479)	(0.479)	(0.479)
F-statistic	49.42***	49.42***	49.42***	49.49***
P-Value	0.000	0.000	0.000	0.000
Kleibergen-Paap	0.000	0.000	0.000	0.000
Anderson Rubin	0.000	0.000	0.000	0.000
Stock-wright	0.000	0.000	0.000	0.000

Conclusion

- I focus on within country variation which might have been externally valid as international copper price was used as an instrument for mine level copper output
- Strong evidence that the pure effect of increased pollution and health outcomes varies significantly by health outcome and type of mine.
- Strong evidence of a link with real incomes and rural/urban status
- Contributed to existing literature and current debate on natural resources and health outcomes by showing the presence of a reverse causality between natural resources and health outcomes
- Extended on a study by Aragon and Rud (2016) on polluting industries and agricultural productivity.

Conclusion

- Policy implications:
  - Help towards policies to promote safe mining and improved health
  - Assist government to design interventions to target priority areas

Thank you and God bless you all!

Q & A